Buckling behavior of straight slot tubesunder oblique loading – A comparative study

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***Abstract*—*Hollow tubes are the most important or crucial parts of the rapidly growing automobile and construction industry. The tube is subjected to pure buckling. In theanalysis, one end is fixed and the force is applied to theother end and by application of different angles of inclinations ranging from 0˚ to 20˚ with different thicknessof the range of 0.5 to 2.0. Linear buckling code was used forfinding the critical buckling load. This research paper is about the effects of buckling under oblique loading. It is the process in which the tube is subjected to compressive oblique loading and the tube fails by the first increase in crossectional area and then bulging on any of the sides but in the case, oblique loading in hollow tube shell bulges internally or inside the perimeter of the tube.*

Keywords*—*buckling load; straight slot; oblique loading; finite element analysis.

I. INTRODUCTION

In the age of globalization and advancement in technology, every automobile industry is focusing primarily to ensure the crash safety without compromising the comfort and fuel efficiency. A detailed study has been carried out for finding the optimal design of structures for so as to act as a safeguard for humans and their stuff. Columns being the preeminent part of any structural design plays the vital role in presaging the structural efficiency. Thin walled tubes due to their light weight, low price, high strength to weight ratio, ease of fabrication is globally preferred over comparable solid section. The behavior of thin-walled tubes is exclusively dependent upon crossectional shapes and material properties. The behavior of tubes changes when their crossectional shape is changed thereby making it an arduous task for finding an optimal design for a circumstantial exercise.

It is evident that the hollow tubes for the intrinsic part of any structure and a lot of attempts have been made by the researchers previously for findingthe individualizedcharacteristics of a differentcross-section such as rectangular, triangular, octagonal, 12 sided star, lateral corrugations toname a few [1-5]. The influence of geometrical features and modifications on the behavior of tubes is presented by Z Fan [6]. The buckling response of tubes can be further enhanced by foam fillers [7]. Thebehavior of tubes are predominantly determined under axial loadingconditions howeverin realcase situationcase situation the structures areseldom subjected to pure axial or pure bending, rather a combination of twobetides. Therefore in order to apprehend the buckling characteristics. of the tubes, the reaction under oblique loading is even more important. The behavior of hollow tubes under static and oblique loading was investigated [8].The previous study shows that the response of tubes under oblique loading can be improved by combining the cross-sectional shapes [9]

The present study has numerically investigated the buckling response of straight slot tube at various angles of inclinations for getting an insight of the effect of oblique loading

NOMENCLATURE	
SS – Straight Slot	T - Thickness
S – Steel	A - Aluminium

II. NUMERICAL SIMULATION

A. Material properties

The material for tubes is aluminum alloy with mass density $\rho=2.7\times10^{-6}$ kg /m^3 and having Young's modulus as 7100Mpa, the poisons ratio as 0.33 and Ultimate tensile strength as 310Mpa and steel is having the mass density $\rho= 8.05\times 10^{-6}$ kg/ m3, Young's modulus as 7,800 kg/m^3 and the poisons ratio as 0.26 and the ultimate tensile strength as 250 Mpa.

B. Finite element model

In this analysis, we use ANSYS with linear buckling module under oblique loading. The specific dimensions of the tube are presented in Table 1. CAD modeling was done in Solidworks. One end is fixed and the other end is free too which load is applied (100 N). The inclinations angles were taken as 0˚, 5˚, 10˚, 15˚, 20˚ as shown in Fig.1.

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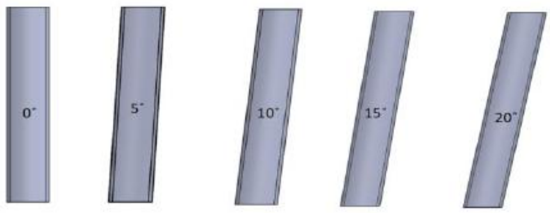

Fig.1. Inclinations under consideration

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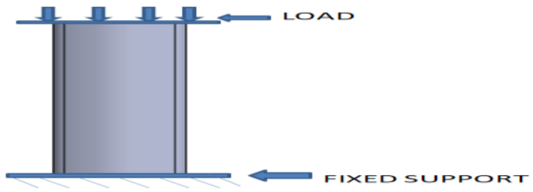

Fig.2. Boundary conditions

The thickness of the tube was taken as 0.5, 1.0, 1.5, and 2.0 while the length of the tubes was kept constant as 100 mm. A detailed geometric specification is presented in Table 1.

Table.1: Geometric configurations

SPECIMEN	THICKNESS	LENGTH	PROFILE
SS-T1	0.5	100	
SS-T2	1.0	100	
SS-T3	1.5	100	
SS-T4	2.0	100	

C. Meshing of geometric profiles

The meshing of the tubes were done in such a manner that the number of elements were almost same in all the different configurations which was corresponding to thousand on an average. A detailed description of the mass of slot tubes as a function of element is given in Table 2.

Table.2: Mass and elements of specimen

ENTITY	MASS (Kg)	ELEMENTS
SS-S-T1	5.5347 e-002	1116
SS-S-T2	0.10947	1080
SS-S-T3	0.16235	1044
SS-S-T4	0.214	1044
SS-A-T1	1.953e-002	1116
SS-A-T2	3.8627e-002	1080
SS-A-T3	5.7287e-002	1044
SS-A-T4	7.5512e-002	1044

III. RESULTS AND DISCUSSION

The objective of this ongoing analysis is to find out about the buckling behavior of straight slot tube under oblique loading. The straight slot geometry with a differentangle of inclinations and different thickness with a constant length (100 mm) is taken for the analysis. The geometry is tested under 5 angles of inclination ranging from 0˚ to 20˚ with the same load of 100 N and further analysis is being made by considering several results like in case of steel maximum peak load are at 0˚ which is 2980.5 and thickness of (2.0) mm while the maximum peak load in case of Aluminum is 1047.8 which is at 0˚ inclination and thickness of (2.0) mm respectively.

Table.3: Buckling load for specimens

Specimen	LOAD MULTIPLIER				
	0˚	5˚	10˚	15˚	20˚
SS-S-T1	64.29	53.41	43.302	35.026	28.29
SS-S-T2	448.76	406.71	349.13	293.26	241.7
SS-S-T3	1355.8	1277.5	1127.4	961.75	798.57
SS-S-T4	2980.5	2860.5	2569.3	2220.7	1852.1
SS-A-T1	22.66	18.79	15.23	338.46	9.9727
SS-A-T2	157.94	143.05	122.8	103.25	85.222
SS-A-T3	476.79	449.12	396.41	338.46	281.19
SS-A-T4	1047.8	1005.5	904.4	781.29	652.55

Fig.3. Buckling load for Steel

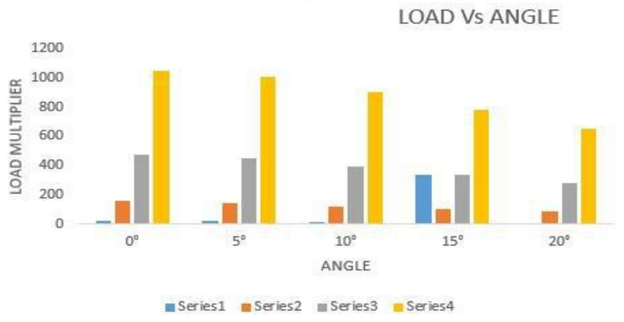

Fig.4. Buckling load for Aluminium

IV. CONCLUSION

The critical load of the straight slot thin-walled tubes was investigated at quasi-static axial and oblique loading numerically. The critical load changes with achange in the thickness and angle of loading. It was found that the value of the critical load may improve but limited to a certain extent. Based on the Numerical observations following conclusions can be wrap up:

- Steel is more stable because its critical buckling load is more than in case of aluminum as per this straight slot geometry is concerned.
- With the increase in the thickness of the slots, the buckling load was rising.
- Clearly further more comprehensive studies are needed to investigate this problem

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